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SHORT-TERM CONTRACTS AND

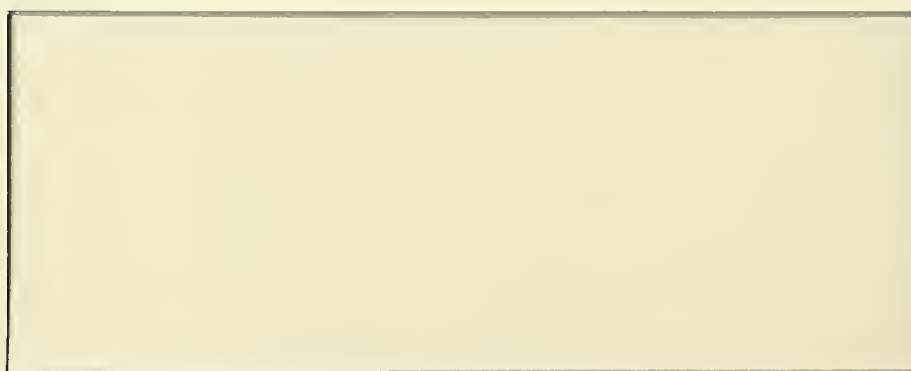LONG-TERM AGENCY RELATIONSHIPS

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1. Introduction

The simplest incentive schemes are probably the piece rate scheme once commonly used for laborers and the commission contract used to compensate salesmen; in both, the worker's pay is proportional to the number of products of various kinds produced. These contracts involve no element of deferred compensation -- each period's pay depends on that period's product -- and neither party pays a penalty when a quit or layoff occurs or when the contract is renegotiated. For these reasons, piece rate and commission contracts can be viewed as a series of very short term contracts, with the worker's pay for any accounting period being the sum of his earnings over each hour or day in the period.

Our purpose here is to investigate when a series of short-term contracts similar to commission contracts can constitute an efficient incentive scheme, and when, to the contrary, the parties would do better to sign a long-term contract that cannot be renegotiated.[1] Long-term contracts enjoy an obvious advantage if they expand the agent's ability to smooth consumption over time, that is, if the firm acts as a banker for a worker who would otherwise have limited access to banking services. But such a rationale cannot explain the observed variation in the length of employment contracts referred to in the opening paragraph. Also, the argument would seem to suggest that low income employees would be on long-term contracts more often than high income employees, since the latter are likely to have easier access to capital markets, and this appears not to be true. We are therefore led to reject the hypothesis

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[1]Commitments to non-renegotiable long-term contracts may be difficult to enforce. It has been suggested that long-term contracts must therefore be renegotiation-proof. We are not concerned with this issue, because our main result will provide conditions under which non-renegotiable long-term contracts are equivalent to a sequence of short-term contracts and hence, a fortiori, to renegotiation-proof long-term contracts.

that consumption smoothing is the main reason for long-term contracts and to search for alternative explanations. To focus attention on other possible advantages of long-term contracts, we will make the unconventional (and extreme) assumption that the employee can borrow and save on the same terms as the firm.

Our major finding is that the following conditions are sufficient for _any_ efficient long-term employment contract to be implementable as a sequence of short-term contracts: At the start of each period, (1) the preferences of the employer and the employee over future contingent outcomes (action-income sequences) are common knowledge, (2) future technological opportunities are common knowledge and (3) the utility possibility frontier at each date, given the preferences at that date, is downward sloping. By the utility possibility frontier at any date, we mean the expected utility pairs that can be achieved using incentive-efficient contracts.

Condition 2 is the one that most clearly varies from job to job, so we will accord it extra attention. Conditions 1 and 2 together specify that there is common knowledge of preferences over contracts at any contracting date. They emphasize that it is the absence of payoff-relevant private information at dates of recontracting that allows short-term contracts to work well.

The main result is derived in two steps. The first step shows that under our conditions, an efficient long-term contract is sequentially efficient in the sense of always providing an efficient continuation from any recontracting date on. For the second step, we need a bargaining solution to determine which sequentially efficient agreements would be reached at each date and in each event if contracts could be renegotiated then. We adopt the solution in which the continuation contract always gives the firm a future payoff (conditional expected present value of future profits) of zero. We then modify the timing

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of payments under the optimal contract so that the firm's future payoff is zero at every date. Since the agent has access to perfect banking services, a mere change in the timing of the agent's compensation affects neither his welfare nor his incentives. Combining steps 1 and 2, any efficient contract with a zero payoff for the firm can be replaced by a sequentially efficient contract with a zero future payoff for the firm at each date and in each event. Since the continuations under this contract always coincide with what the parties would have agreed to anyway given our assumed bargaining solution, there is no gain to long-term contracting.

We emphasize failures of Condition 2 as the major factor in determining the value of long-term contracts. As an example, consider the problem of compensating an executive when this year's investment decisions and next year's operating decisions jointly determine next year's profits. An optimal long-term contract will generally distort next year's compensation to create incentives for efficient investment this year. So, next year's continuation of the contract will not be an efficient solution to next year's contracting problem: The optimal long-term contract is not sequentially efficient.

Section 2 introduces the model and the contracting modes that we will be considering. Section 3 illuminates the common knowledge conditions by providing examples in which their failure results in efficient long-term contracts that are not sequentially efficient. Section 4 develops our results in a general model. Section 5 explores a more specialized model in which the agent's preferences are additively separable over time and exponential in each period's consumption and his consumption and savings decisions are unobservable. With unobserved savings, condition 1 requires that the agent's wealth not influence his preferences, which is the reason we assume exponential utility. We investigate the situation when the technology is of a kind that seems most

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relevant for factory laborers and some salesmen: Each period's efforts are assumed to affect only that period's production. We show that if the environment is stationary, the optimal long-term contract prescribes piece rates and commission schemes, which can be achieved with short-term contracts. This contrasts with the executive compensation case discussed above, where commitment to long-term contracts is necessary for optimality.

The properties of our model when the interest rate is small are studied in section 6, where our conclusions are analyzed in relation to the literature on "folk theorems" in game-theoretic models with moral hazard. Section 7 is devoted to extensions. Here we take up several issues, including the relationship of our results to the literature on incomplete contracting, the important distinction between long-term contracts and long-term job attachments, and multiagent ("free rider") contracting problems. Some concluding remarks follow in section 8.

2. <u>The Model</u>.

We consider a multi-period principal-agent model with time indexed $t=0,1,\ldots$. Periods are to be construed as the minimum length of time of commitment to a contract or alternatively as dates of potential renegotiation; of course, long-term contracts may permit commitments beyond one period. Within each period, the agent consumes, observes a private signal, acts, and receives a payment from the principal, in that order. Without loss of generality, we specify that the agent commits himself to an action strategy (a function from signals to acts) before observing the signal. We will denote the agent's <u>consumption</u> in period t by c_t, his <u>signal</u> by σ_t, and his <u>action strategy</u> (hereafter just <u>action</u>) by e_t ("effort"). After the agent has acted, an <u>outcome</u> x_t is observed by both sides. The outcome includes the principal's

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period-t _profit_ π_t. This is modelled by specifying that $\pi_t = \pi_t(x_t)$. After x_t is observed, the principal makes a _payment_ s_t to the agent. This concludes the events in period t.

Consumption c_t is a real number, possibly constrained to lie in some convex consumption set. The action e_t includes any choice about which the agent cares directly and which affects the outcome of the firm as well as any messages that the agent may transmit concerning his private information. The joint distribution of the signals $(\sigma_0, \ldots, \sigma_T)$ is exogenously specified.

The publicly observed outcome x_t includes all information that first becomes public in period t, including any messages transmitted by the agent, but excluding the agent's consumption. Throughout the paper we will assume that all jointly observed information can be used in contracting. We do not make a distinction between observable and verifiable information.

Histories are denoted by superscripts. Thus, $e^t = (e_0, \ldots, e_t)$, $c^t = (c_0, \ldots, c_t)$, $\sigma^t = (\sigma_0, \ldots, \sigma_t)$ and $x^t = (x_0, \ldots, x_t)$. The full history of events and decisions through time t is denoted $z^t = (x^t, e^t, c^t, \sigma^t)$. The public information at time t is $h^t = x^t$ if consumption is not observed or $h^t = (x^t, c^t)$ if consumption is observed. At the end of period t, the agent knows z^t and the principal knows h^t.

To avoid some technical complications, we will assume that there is a _terminal date_ T after which there are no further effects on profits from the agent's actions, no further payments from the principal to the agent and no further information arriving. Formally:

Assumption 1 (Finite Contract Term). For $t \geq T+1$, $\pi_t = 0$, $x_t = 0$ and $s_t = 0$.

The agent may (but need not) continue to consume forever (in one of our

applications this is essential; see section 5). However, we will not model
this explicitly in the main analysis. Instead we will express post-T consumption
preferences in the form of an indirect utility over terminal wealth w_{T+1}.
The agent's wealth is determined by his savings and borrowing options to be
specified below.

The von Neumann - Morgenstern utility of the agent is initially specified
as:

(2.1) $\qquad U(c_0, \ldots, c_T, e_0, \ldots, e_T, \sigma_0, \ldots, \sigma_T, w_{T+1}),$

Special cases of (2.1) will come up later. The principal is risk neutral and
evaluates profit and payment streams through their net present value:

(2.2) $\qquad \sum_{t=0}^{T} \delta^t [\pi_t - s_t].$

The stochastic technology determines the link between the agent's actions
and the outcomes. It is described by a set of probability distributions $\{F_t: t = 0, \ldots, T\}$ over outcomes. The distribution $F_t(x_t | z^{t-1}, e^t)$ depends in general on
the public outcome history as well as on the agent's accumulated private
information (z^{t-1}) and his period t action. Thus, the outcomes in different
periods can be stochastically dependent as well as time dependent. Note that
our specification also permits the agent to be inactive in any period (by
assuming that his action in that period is without consequence); in particular,
he may retire before the contract termination date T. We require that the
support of F_t be independent of (z^{t-1}, e^t), that is, shirking can never be
detected with certainty.

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Let $\{c_t(z^{t-1})\}$ and $\{e_t(z^{t-1})\}$ denote the agent's _plans of consumption and action_. Since the agent acts and consumes before the period t outcome is realized, the period t plan is a function of histories up to time t-1. We will often write e for the agent's effort plan and c for his consumption plan.

A _long-term contract_ is a triple (e,c,s), where (e,c) are to be construed as instructions (or suggestions) for the agent's (contingent) effort and consumption plans (see above) and $s = \{s_t(x^t)\}$ specifies the payments from the principal to the agent as a function of the contractual variables. Alternatively, we could have called just s a long-term contract. The two definitions will be equivalent under the incentive compatibility constraint that we will impose.

In order to isolate the incentive concerns from the issue of intertemporal smoothing of consumption we will assume that the agent has free access to a bank.

Assumption 2 (Equal Access to Banking). The agent can borrow and save at a secure bank, with a savings or loan balance of 1 at the end of today growing to $1/\delta$ at the beginning of tomorrow. The bank allows the agent to borrow and save any amount up to time T. Post-T transactions are embodied in the agent's preferences over terminal wealth.

With this banking assumption, the wealth of the agent at the beginning of period t, w_t, is defined as

$$(2.3) \qquad w_t(z^{t-1}) = \delta^{-t}[w_0 + \sum_{\tau=0}^{t-1} \delta^\tau (s_\tau(x^\tau) - c_\tau(z^{\tau-1}))],$$

where w_0 is the wealth that the agent starts out with. To indicate explicitly that w_{T+1} depends on c and s we will sometimes write $w_{T+1}(c,s)$.

Remarks.

1. Assumption 2 implies that the agent can access the bank on the same terms as the principal, who also discounts payments at the rate δ.

2. Banking may lead to a negative balance at the end of time T, and hence negative consumption afterwards. If desired, this possibility can be ruled out by specifying the utility function over terminal wealth w_{T+1} so that the agent voluntarily keeps w_{T+1} nonnegative. Nonnegativity constraints on levels of wealth w_t for $t \leq T$, however, are restrictions that create a potential banking role for the employer, and we exclude them.

3. Two contracts $\{s_t(x^t)\}$ and $\{\bar{s}_t(x^t)\}$ which have the same net present values along every realized path x^T give the agent the same consumption opportunities. Consequently and importantly, the agent will behave identically under the two plans. Furthermore, the principal will be indifferent between the two contracts, because the agent behaves the same way and the net present values of payments are the same.

Definition. A long-term contract (e,c,s) is incentive compatible if the agent finds it optimal to follow the instructions (e,c), that is, if:

(2.4)   (e,c) Maximizes $E_{\hat{e}}[U(\hat{e},\hat{c},\sigma^T,w_{T+1}(\hat{c},s)]$.
                 $(\hat{e},\hat{c})$

The expectation in (2.4) is taken with respect to the distribution of the stochastic process $\{z_t\}$ generated by the agent's plan $(\hat{e})$ as indicated by the subscript. When no confusion can arise we may drop the conditioning in what

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follows. We will frequently refer to an incentive compatible long-term contract simply as a long-term contract.

Definition. An incentive compatible long-term contract is efficient if there is no other incentive compatible long-term contract that both parties prefer. An efficient contract that provides expected profits $\bar{\pi}$ to the principal solves:

$$\underset{(e,c,s)}{\text{Maximize}} \quad E_e[U(e,c,\sigma^T,w_{T+1}(c,s))], \qquad \text{subject to}$$

(i) program (2.4),

(2.5) and

(ii) $\displaystyle\sum_{t=0}^{T} \delta^t E_e[\pi_t - s_t(x^t)] \geq \bar{\pi}.$

Definition. An efficient long-term contract that provides the principal with zero expected profits is called optimal.

Our definition of optimality reflects an implicit assumption that the market will force the principal to offer the agent the best zero profit contract. This same market constraint will be imposed in each period in our definition of sequential optimality below.

Definition. A long-term contract is sequentially efficient if for any history x^τ the contract is an efficient solution to the contracting problem after that history, under the assumption that the agent's unobserved behavior up to time τ accords with instructions. Formally, (e,c,s) is sequentially efficient if it

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is efficient when the single incentive constraint (2.4) is replaced by the set of constraints that for all $\tau = -1, \ldots, T-1$ and h^τ,

(2.6) (e,c) Maximizes $E_{\hat{e}}[U(\hat{e}, \hat{c}, \sigma^T, w_{T+1}(\hat{c}, s)) | h^\tau]$,
             $(\hat{e}, \hat{c})$

subject to the restriction $\hat{e}^\tau = e^\tau$ for the case $h^t = x^t$ and to the restrictions $\hat{e}^\tau = e^\tau$ and $\hat{c}^\tau = c^\tau$ for the case $h^t = (x^t, c^t)$.

Notice that a sequentially efficient contract is not the same as an efficient long-term contract designed subject to the additional constraint that there is no desire to renegotiate it. (Such renegotiation-proof contracts are analyzed by Dewatripont (1986) and Hart and Tirole (1986).) A sequentially efficient contract is characterized by a set of conditions stating that it is an efficient long-term contract (under full commitment) from each event onwards. As we show in the next section sequentially efficient contracts may not exist.

Intuitively, sequential efficiency is a necessary condition for there to be no gains from commitments to long-term contracts. For if we posit a process of renegotiation such that the continuation agreement at each date is efficient (given the parties' then current information and beliefs), then a contract that is not sequentially efficient cannot survive renegotiations. In that case, there are clear gains to be had from committing to a long-term contract.

A sufficient condition for there to be no gains to long-term contracting is that the consumption, action, and compensation plans of an optimal long-term contract coincide at each date with those that would then be negotiated. To verify when this sufficient condition holds, one must know what the equilibrium outcome would be under a regime of short-term contracts. That poses a grave

difficulty when there is asymmetric information at the recontracting dates, since the reasonable solutions concepts for such bargaining problems are still very much in doubt. Our notion of sequential optimality, as defined below, is intended to be a reasonable specification only for environments in which there is no relevant asymmetric information at recontracting dates and competition among employers force the firm's future payoff to be zero at each date.

Definition. A sequentially efficient long-term contract is <u>sequentially optimal</u> if it satisfies:

$$(2.7) \qquad \sum_{t=\tau}^{T} \delta^{t-\tau} E_e[\pi_t - s_t(x^t)|z^\tau] = 0 \text{ for every } \tau, z^\tau.$$

3. Examples of Sequential Inefficiency.

As we said in the Introduction, efficient long-term contracts need not be sequentially efficient when the Common Knowledge or Decreasing Utility Frontier conditions are not satisfied. When the latter condition fails, there are some dates and utility levels for the agent for which no efficient continuation contract exists. If those utility levels must be used to provide efficient incentives in the long-term contract, then it is plain that no sequentially efficient contract will exist.

The examples in this section illuminate the subtler Common Knowledge conditions. Example 1 is a long-term contracting problem where the agent's first period action influences both first and second period outcomes, as when the first period action is an investment decision. The problem is formally equivalent to a single period problem with two information signals. A familiar

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result for such models (Holmstrom (1979), Shavell (1979)) is that the agent's compensation will optimally depend only on the first signal if and only if the first signal is a sufficient statistic for the agent's action. In this example, the Common Knowledge and sufficient statistic conditions are identical. When this condition fails, the second period compensation must be used to help provide incentives. Hence, it must differ from the sequentially efficient compensation (which is deterministic).

Example 2 is another two-period contracting problem, but in it the agent acts only in the second period. If he were to observe in the first period private information about his second period preferences and if he were given optimal incentives to report his information truthfully, the incentives would often require distortions in the second period contract. The optimal long-term contract would not then be sequentially efficient. In our example, a similar distortion arises because the agent has private information about his first period consumption choice, which affects his second period preferences through his wealth. Both kinds of private information about preferences give rise to adverse selection at recontracting dates (Milgrom (1987)), and in this context as in others they lead to inefficiency. The Common Knowledge conditions state precisely that there is no adverse selection of any kind at any contracting date.

Example 1. There are two periods; $t=0,1$. The agent works only in the first period but output and consumption take place in both. Work involves choosing either a high level of effort or a low level of effort; $e_0 = H$ or L. As a consequence of the agent's choice, a productive outcome y_t occurs in each period t according to the probability mass function $f(y_0, y_1 | e_0)$.

The agent is risk and work averse. His preferences are represented by a

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utility function of the form: $U(e_0, c_0, c_1) = u(c_0) - v(e_0) + u(c_1)$, where for concreteness we let $v(H) = 1$ and $v(L) = 0$. To economize on variables, we take the period 1 consumption to occur at the end of the period: There is then no terminal wealth. There is no discounting; the interest rate is zero; and the function u is increasing, strictly concave, and unbounded from below.

We assume that the publicly observed outcomes are $x_0 = (c_0, y_0)$ and $x_1 = y_1$. Because the agent works only once, this is essentially a standard "single-period" agency model with the twist that the outcome is revealed over time. Let $(e_0^*, c_0^*, c_1^*, s_0^*(x_0), s_1^*(x_0, x_1))$ be an optimal long-term contract. We assume that $e_0^* = H$, i.e. it pays to induce a high level of effort.

A standard single-period analysis shows that the agent's optimal period one consumption must generally depend on y_1 unless y_0 is a sufficient statistic for e_0, that is, unless $f(y_1|e_H, y_0) = f(y_1|e_L, y_0)$ for all (y_0, y_1). This is also the condition that the agent's beliefs about the period 1 outcome at the end of period zero depend only on the common knowledge observation y_0, and not on his private information about e_0. When this common knowledge/sufficient statistics condition fails to hold, s_1 will depend nontrivially on y_1. However, efficient risk sharing in period 1 requires that the continuation contract fix s_1 independently of y_1, so the optimal long-term contract in this case is not sequentially efficient. We conclude that when information about the agent's action is revealed slowly over time, the parties may suffer an efficiency loss if they cannot commit themselves not to renegotiate.

Example 2. Let us retain the form of the agent's preferences and the banking assumption from Example 1 and but change the work environment and technology as follows. The agent works only in the second period and production takes place then. The productive outcome may be either a success (S) or a failure (F).

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The probability of success is p if the worker supplies high effort and q < p if he supplies low effort. Consumption is not observed, so contracts cannot be indexed on it. Again, we shall argue that the optimal long-term contract is not sequentially efficient so that efficiency is enhanced if the parties can commit themselves not to renegotiate their contract.

To verify this, let us first examine the two-period efficient contract. Since only the outcome of the worker's effort is observed the compensation scheme takes the form $(s_0, s_1(y_1))$. Without loss of generality, we can take s_0 = 0. To simplify notation, write $s_1(S) = w_S$, $s_1(F) = w_F$ and $c_0 = c$. An optimal compensation scheme is a solution to:

(3.1)
$$\underset{\hat{c}, w_F, w_S}{\text{Max}} \ u(\hat{c}) + pu(w_S - \hat{c}) + (1-p)u(w_F - \hat{c}) - 1 \ .$$

subject to

$$u(\hat{c}) + pu(w_S - \hat{c}) + (1-p)u(w_F - \hat{c}) - 1$$

(3.2)
$$= \underset{c}{\text{Max}} \ u(c) + pu(w_S - c) + (1-p)u(w_F - c) - 1$$

$$\geq \underset{c}{\text{Max}} \ u(c) + qu(w_S - c) + (1-q)u(w_F - c) \ , \text{ and}$$

(3.3)
$$pw_S + (1-p)w_F \leq \bar{w} \ .$$

This optimization problem incorporates an incentive constraint (3.2) and a participation constraint (3.3). The incentive constraint requires that the worker would rather work diligently than shirk, given that in each case he can adapt his consumption decision to his effort choice, and that the consumption choice contemplated in the contract is the preferred choice of a diligent worker. The maximization over first period consumption c in this constraint reflects the assumption that the worker can finance his consumption plan by borrowing from a "bank" at a zero rate of interest. The participation con-

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straint specifies a maximum expected wage (and hence a minimum expected profit) for the firm as in (2.5) (ii).

At an optimal solution $(\hat{w}_S, \hat{w}_F)$ to the problem (3.1)-(3.3), $\hat{w}_F < \hat{w}_S$; otherwise the no-shirking constraint (3.2) cannot be satisfied. Let c_H be the optimal choice of initial consumption for a worker who plans to work hard and c_L the optimal choice for a worker who plans to be lazy. These are unique since u is strictly concave. The first-order conditions determining the consumption choices are,

$$u'(c_H) = pu'(\hat{w}_S - c_H) + (1-p)u'(\hat{w}_F - c_H) \text{ , and}$$

$$u'(c_L) = qu'(\hat{w}_S - c_L) + (1-q)u'(\hat{w}_F - c_L) \text{ ,}$$

From these equations and the facts that $\hat{w}_F < \hat{w}_S$, $p > q$ and u' is decreasing, it follows that $c_H > c_L$. The worker consumes more in the first period when he plans to be diligent because his income is (stochastically) greater then and first-period consumption is a normal good.

Now suppose that the parties sign the optimal long-term contract and that the employee, planning to be diligent, consumes c_H. Once he has made the initial consumption decision, the employee strictly prefers to work hard in the second period, as seen from:

$$\begin{aligned}
&u(c_H) + pu(\hat{w}_S - c_H) + (1-p)u(\hat{w}_F - c_H) - 1 \\
(3.4) \quad &\geq u(c_L) + qu(\hat{w}_S - c_L) + (1-q)u(\hat{w}_F - c_L) \\
&> u(c_H) + qu(\hat{w}_S - c_H) + (1-q)u(\hat{w}_F - c_H).
\end{aligned}$$

The first inequality in (3.4) is just a restatement of the incentive-compati-

bility condition (3.2); the second follows because c_L is the unique optimal choice for an agent who plans to shirk.

Once we see that the incentive constraint does not hold with equality along the equilibrium path, it is clear that the optimal long-term contract is not sequentially efficient: Given that the agent has consumed c_H, an efficient continuation contract must make the agent just indifferent about his choice of effort. More precisely, the following equality will hold:

$$(3.5) \qquad p(u(w_S - c_H) + (1-p)u(w_F - c_H) - 1 =$$
$$qu(w_S - c_H) + (1-q)u(w_S - c_H) .$$

However, according to (3.4), the wages $(\hat{w}_S, \hat{w}_F)$ specified by the unique optimal two period contract do not satisfy (3.5).

We conclude that private information about preferences at contracting dates ("adverse selection") can cause optimal contracts not to be sequentially efficient. In such cases, commitments to a non-renegotiable long-term contract can be of benefit to both parties.

4. Main result.

We begin by formalizing common knowledge of technology and preferences. Since the agent has more detailed information than the principal at all times (he knows z^t when the principal only knows x^t), the principal's information is always common knowledge. Thus, the assumptions on common knowledge only involve limitations on the agent's information advantage.

Assumption 3 (Common Knowledge of Technology). At the end of each period t and for all possible histories z^{t-1},

$$(4.1) \qquad F_t(x_t|z^{t-1},e_t) - F_t(x_t|x^{t-1},e_t).$$

Assumption 3 says that the information provided in the commonly known history x^{t-1} is sufficient for determining the relationship between the agent's action strategy and the outcome distribution in period t. The Assumption is satisfied if the x_t's are independent with distributions parameterized by the e_t's and the σ_t's are either independent over time or commonly observed. We stress, however, that (4.1) permits past actions to affect current outcomes. For instance, the following Markov technology satisfies (4.1):

$$(4.2) \qquad x_t - x_{t-1} + e_t + \epsilon_t,$$

where the ϵ_t's are independent stochastic disturbances unobserved by both parties. More generally, x_t could be a vector that includes public information about the economy, the industry or the particular technology that the agent operates and it may indicate the agent's current consumption. Assumption 3 does imply that x_t conveys no new information about past actions e^{t-1}.

Examples of technologies which violate the common knowledge assumption include the following:

$$(4.3) \qquad x_t - e_t + e_{t-1} + \epsilon_t,$$

$$(4.4) \qquad x_t - e_t + \epsilon_{t-1} + \epsilon_t.$$

Both specifications violate (4.1). In both cases, if e_t were known, x_t could
be used to improve an estimate of e_{t-1}.

To state the common knowledge assumption about preferences over contracts
expressed as contingent action-income streams, we need some additional nota-
tion. Let $\bar{e} = (e_{t+1}, \ldots, e_T)$ and $\bar{s} = (s_{t+1}, \ldots, s_T)$ denote future random action
and income streams. Let P be a probability measure over $(\bar{e}, \bar{s})$ and let E_P
denote expectations with respect to the measure P (the exogenously specified
distribution of σ^T is held fixed). Letting c denote a consumption plan, we
define

$$V_t(P|z^t) = \max_c E_P[U(\bar{e}\backslash e^t, c\backslash c^t, \sigma^T, w_{T+1}(c\backslash c'\bar{s}\backslash s^t))|\sigma^t]$$

This represents the maximal expected utility that the agent can obtain by
choosing an optimal consumption plan for the future given the history of past
consumptions, signals, and outcomes and a probability measure P over the random
stream $(\bar{e}, \bar{s})$. Thus, the value V_t refers to preferences over probability
distributions of <u>future</u> action-payment streams. The following assumption
asserts that these preferences are common knowledge.

<u>Assumption 4</u> (Common Knowledge of Preferences). For all t and any two distri-
butions P and R,

(4.5) $\{z^t: V_t(P|z^t) > V_t(R|z^t)\} \in \sigma(h^t)$

where $\sigma(h^t)$ is the σ-algebra generated by h^t.

Assumption 4 can be satisfied in several ways, all involving some form of intertemporal separability of preferences. Thus, if the σ_t's are statistically independent and agent's utility is either additively separable

$$(4.6) \qquad U(\bar{e},\bar{c},w_{T+1}) = \sum_{t=0}^{T} \delta^t u_t(c^t,e_t,\sigma_t) + g(w_{T+1})$$

or multiplicatively separable

$$(4.7) \qquad U(\bar{e},\bar{c},w_{T+1}) = \prod_{t=0}^{T} u_t(c^t,e_t,\sigma_t)g(w_{T+1})$$

and if the agent's consumption is observable, then the assumption is satisfied. Separability assures that past efforts do not affect preferences over future action-income distributions, and the agent's only private information in this specification concerns these past efforts. The various special cases of (4.6) with each period's consumption observable has been studied frequently. Allen (1985) and Green (1984) adopted the "repeated insurance problem" version of this model, which is defined by the additional restrictions that $u_t = u_t(c_t,\sigma_t)$ and that the σ_t's are independent over time. Laffont and Tirole (1986) and Baron and Besanko (1987) studied a similar model but with $\sigma_0 = \sigma_1$ - a crucial difference because it causes Assumption 4 to fail. Malcomson and Spinnewyn (1986) and Rogerson (1985) treated models satisfying (4.6) with the restriction $u_t = u_t(c_t,e_t)$.

Even when consumption is not observable, Assumption 4 is satisfied provided there are no wealth effects on preferences. This happens in (4.7) if in addition

$$(4.8) \qquad u_t = \exp[-r(c_t - v(e_t,\sigma_t))] \quad \text{and} \quad g(w_{T+1}) = -\exp[-rw_{T+1}].$$

The preferences resulting from (4.7) and (4.8) with $v(e_t, \sigma_t) = v(e_t)$ were used in the principal-agent models of Fellingham, Newman, and Suh (1985) and Holmstrom and Milgrom (1987). Our main theorem below applies to each of these models as well as the ones mentioned earlier, thus helping to clarify the relationships among them. In Section 5 we shall study another model without wealth effects to which our theorem applies, one in which the agent's consumption is unobserved and preferences are additively separable ((4.6) holds).

The significance of common knowledge is the following. If Assumptions 3 and 4 are satisfied, the principal knows how the agent orders different long-term contracts, not just at time t = 0, but also conditional on any history z_t. Also, the agent knows the principal's preferences over contracts, because the agent has finer information. Consequently, there will be no adverse selection problem to overcome in negotiating the contract at time t. Next, we develop the assumption that the utility possibility frontier slopes downward, along with conditions on the agent's preferences sufficient to ensure that the assumption is satisfied.

Definition. The _utility possibility frontier_ at date t, given z^t, is the locus of pairs of conditional expected utility and profit $(\hat{u}_t, \pi_t(\hat{u}_t; z^t))$ such that the expected profit is maximized over all incentive compatible long-term contracts (e, c, s) subject to the constraint that the agent's expected utility is precisely $\hat{u}_t$.

Assumption 5 (Decreasing Utility Frontier). The function $\pi_t(\hat{u}_t; z^t)$ is decreasing in $\hat{u}_t$.

<u>Theorem 1</u>. If w_{T+1} is common knowledge at time T (as it is if consumption decisions are observed), then Assumption 5 is satisfied when either of the following two conditions hold.

(i) Preferences satisfy (4.6) (additive separability over time) and the function g is increasing, continuous, and unbounded below.

(ii) Preferences satisfy (4.7) (multiplicative separability over time), each u_t is positive, the function g is increasing and continuous, and either g is negative and unbounded below or it is positive and has greatest lower bound zero.

<u>Proof</u>. Pick any incentive-compatible contract (s,e,c), and any positive constant k. Using a representation of preferences that satisfies (i), we shall construct another incentive-compatible contract (s*,e,c) such that the agent's utility is reduced by k and the principal's utility is increased.

The new contract calls for the same actions, consumptions, and compensations as the original except that the final payment only is reduced, being calculated so that $g(w_{T+1}+s^*_{T+1}-s_{T+1}) = g(w_{T+1}) - k$. (This is always possible because g is increasing, continuous and unbounded below.) With this specification, the agent's utility for any choice and any random outcome is less by the amount k in the new contract than in the old, so the new contract is indeed incentive-compatible and reduces the agent's utility by k compared to the original contract. Since the new contract pays less in every event, it raises the principal's expected profit. Hence, for every point on the utility possibility frontier and any lower level utility for the agent, there is a feasible point with the specified lower utility for the agent and greater expected profits for the principal. Hence, the initial utility-possibility frontier is downward sloping. The same construction works for continuation contracts, so condition (i) is proved to be sufficient. The sufficiency of condition (ii) can be

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proved in a similar fashion. ∎

For the case of observable consumption, when either condition of Theorem 1
is satisfied, we have already seen that Assumption 4 holds. Hence, these
conditions imply all of the assumed restrictions on preferences that we shall
need for Theorem 2. This establishes that the conditions of the next theorem
are not vacuous, as well as providing a simple way to generate examples.

Theorem 2. Suppose that Assumptions 1 (Finite Contract Term), 2 (Equal Access
to Banking), 3 (Common Knowledge of Technology), 4 (Common Knowledge of
Preferences) and 5 (Decreasing Utility Frontier) hold. If there is an optimal
long term contract, then there is a sequentially optimal contract, which can be
implemented via a sequence of short term contracts.

We prove the theorem in two steps, as described in the introduction. The
first step is of independent interest, partly because it does not require the
banking assumption and partly because it serves as the basis for later exten-
sions of our results. Its conclusion is stated below.

Theorem 3. Under Assumptions 1 and 3-5, for any efficient long term contract,
there is a corresponding sequentially efficient contract providing the same
expected utility and profit levels.

Proof. Assume that (e,c,s) is an efficient long term contract. Suppose it is
not sequentially efficient. There is a minimal t such that for some public
history $\hat{x}^t$, the continuation contract $[e,c,s](\hat{x}^t)$ beginning at time t after
that history is Pareto dominated by another incentive compatible continuation

contract. By Assumption 5, for each such $\hat{x}^t$, there is another incentive compatible continuation contract $(\hat{e},\hat{c},\hat{s})$ that provides the same conditional expected utility to the agent and a higher conditional expected profit to the principal than the original contract does under the assumption that the agent followed the instructions up until event x^t occurred. By Assumptions 3 and 4, the agent's and the principal's ranking of contracts depends only on the observable x^t and not on the additional information in z^t. Therefore, whether the agent has followed instructions or not, the alternative contract provides the same expected utility to the agent as the original contract and higher conditional expected profits for the principal.

Now construct a new contract that differs from the original contract only in that its terms once an event $\hat{x}^t$ occurs are those specified by $(\hat{e},\hat{c},\hat{s})$. We claim the revised contract is incentive compatible. First note that for all z^t such that $x^t(z^t) = \hat{x}^t$, the agent's conditional expected utility must be the same since the agent's preferences are determined by x^t alone. Second, all continuation expected utilities conditional on any other z^t, since the consequent terms are unchange. By the Optimality Principle of Dynamic Programming, the agent's incentives up to time t are unchanged and his expected utility is unchanged. The principal is in all events (weakly) better off at time t. Finally, the new contract has efficient continuations at every date up to and including time t. Iterating the process up to date T enables one to construct a sequentially efficient contract. ∎

Proof of Theorem 2. Let (e,c,s) be the optimal long term contract. By Theorem 2, we can take it to be sequentially efficient. Denote by $\Pi_t(x^{t-1})$ the principal's expected profits at the beginning of period t, given the outcome history x^{t-1}.

$$\Pi_t(x^{t-1}) = \sum_{\tau=t}^{T} \delta^{\tau-t} E_e[\pi_t - s_t | x^{t-1}].$$

By the definition of optimality, $\Pi_0(x^{-1}) = 0$. By Assumption 1, $\Pi_t(x^{t-1}) = 0$ for $t \geq T+1$.

We will modify the timing of payments to make expected profits zero from each node x^t onwards. Let

(4.9) $\hat{s}(x^t) = s(x^t) - \delta\Pi_{t+1}(x^t) + \Pi_t(x^{t-1}),$ for $t = 0,1,\ldots,T.$

For every sequence of outcomes, the present value of the agent's compensation is the same under $\hat{s}$ as under s (by telescoping series), so $(\hat{s},e,c)$ is incentive compatible (c.f. remark 3 after Assumption 2). By construction expected profits are zero from each node onwards. By definition, the contract $(\hat{s},e,c)$ is therefore sequentially optimal.

We have already explained the equivalence of sequential optimality and sequential short term contracting. ∎

5. Additively Separable Exponential Utility.

While preferences in a multiperiod model will in general not be common knowledge and therefore could provide a theoretical reason for long term contracting, we do not think this is an empirically significant reason. Firms seem to make little effort to monitor employee wealth, which would be of value if wealth effects were important. It seems reasonable therefore to look for an explanation of observed contract characteristics using models in which Assumption 4 (Common Knowledge of Preferences) is satisfied even when consumption is

not observable. One such model is specified below.

The agent observes no periodic private signals σ_t. Preferences display constant absolute risk aversion and additive separability over time, as follows:

Assumption 6 (Exponential Utility). .The agent's utility function is

$$(5.1) \qquad - \sum_{t=0}^{\infty} \delta^t \exp\{-r(c_t - v(e_t))\}, \quad \text{with } v(e_t) = 0 \text{ for } t > T.$$

Assuming that the agent has access to a bank in all periods using the same discount factor δ as that in (5.1), he will find it optimal after period T to consume just the interest on his terminal wealth w_{T+1}:

$$(5.2) \qquad c_t = (1-\delta)w_{T+1} \text{ for } t > T.$$

Consequently, the specification (5.1) corresponds to (4.6) with

$$(5.3) \qquad g(w_{T+1}) = - \delta^{T+1}(1-\delta)^{-1}\exp\{-r(1-\delta)w_{T+1}\}.$$

Theorem 4: If Assumptions 1 (Finite Contract Term), 2 (Equal Access to Banking) and 6 (Exponential Utility) hold, then Assumptions 4 (Common Knowledge of Preferences) and 5 (Decreasing Utility Frontier) are also satisfied.

Proof: Fix τ, $0 < \tau < T$, and a history z^τ. Let $w_{\tau+1}$ be the agent's wealth at the beginning of period $\tau+1$ as defined earlier in (2.3). This is fixed given z^τ.

Define $d_t = c_t - (1-\delta)w_{\tau+1}$, for $T \geq t \geq \tau+1$. This represents consumption

in excess of interest on the wealth the agent has at the beginning of time $\tau+1$. Simple algebra will show that

$$(5.4) \qquad w_{T+1} = w_{\tau+1} + \sum_{t=\tau+1}^{T} \delta^{t-T-1}(s_t - d_t).$$

Consequently, the agent's preferences at time τ over future consumption-effort streams can be represented by

$$(5.5) \quad -u((1-\delta)w_{\tau+1}) \left[\sum_{t=\tau+1}^{T} \delta^t u[d_t - v(e_t)] + \delta^{T+1}(1-\delta)^{-1} u[(1-\delta)(w_{T+1} - w_{\tau+1})] \right]$$

where $u(y) = -\exp(-ry)$. To establish (5.5) we have used the fact that $u(yz) = -u(y)u(z)$ as well as the representation (4.6) and (5.3) of the agent's utility function.

Given a probability distribution P over income effort streams, we compute $V_\tau(P|z^\tau)$ by maximizing (5.5) over consumption plans, or equivalently over d. After substituting (5.4) into the last parenthesized expression in (5.5), it becomes transparent that the utility-maximizing plan d does not depend on z^τ, and hence that V takes the following form for some functions H and h with $H(P) = -u[(1-\delta)h(P)]$:

$$(5.6) \qquad V(P|z^\tau) = u[(1-\delta)w_{\tau-1}]H(P) = u[(1-\delta)(w_{\tau-1}+h(P))]$$

Assumption 4 follows immediately from (5.6). In intuitive language, the agent's preferences over contracts are fully determined by $H(P)$, which does not depend on z^τ. We have seen earlier that with additively separable utility, history affects current preferences only through wealth effects. In deriving equation (5.6) we have established that, with exponential utility of periodic

consumption, wealth effects are absent, too, so preferences are common know-
ledge.

Assumption 5 also follows from (5.6). A reduction of a fixed amount in
the agent's compensation in any period (say, the first) does not affect his
preferences over lotteries. Hence, such a reduction preserves incentive-
compatibility, lowers the agent's utility, and raises the principal's expected
profits. This shows that the initial utility possibility frontier is downward
sloping, and a similar argument applies to renewal dates. ∎

In view of Theorem 4, the conclusion of Theorem 2 applies when Assumptions
1-3 and 6 hold. We can obtain stronger conclusions by strengthening Assumption
3. Assumption 7 asserts that the technological opportunities in any period t,
besides not depending on private historical information as in Assumption 3, do
not even depend on the common knowledge information; they are a function of the
date only. Assumption 8 is a further strengthening in which even the date is
irrelevant for determining technological opportunity because the environment is
stationary.

Assumption 7 (History-Independent Technology). For all $0 \leq t \leq T-1$,
$F_t(x_t | z^{t-1}, e^t) = F_t(x_t | e_t)$.

Assumption 8 (Stationary, History-Independent Technology). For all $0 \leq t \leq T-1$, $F_t(x_t | z^{t-1}, e_t) = F(x_t | e_t)$.

According to Assumption 7, the outcome at date t depends on date t actions
alone, and not on past outcomes or actions. We take this assumption to be a
tolerable approximation for the work of a laborer engaged in a repetitive task,

where the outcome of each successive operation affects the quality of one
particular item, or the effort exerted over each item affects the time to
completion for that item. The assumption might also apply to one who sells
consumer goods, abstracting from any unobserved investments the salesman may
have to make in such things as his reputation, knowledge of the stock and
current styles, etc. For such situations, the optimal incentive compensation
schemes are modified piece-rate or commission rules, in which the commission
rate or piece-rate may vary over time. It is obvious that when such rules are
optimal, a long-term employment relationship does nothing to alleviate the
incentive problem. With the additional assumption that the environment is
stationary, a standard commission or piece-rate scheme emerges as optimal.

Theorem 5: Suppose that Assumptions 1, 2, 6, and 7 hold and that there is some
optimal long-term contract. Then there is an optimal contract for which:

(i) current instructions and payments do not depend on past performance:
$e_t(x^{t-1}) = e_t$ and $s_t(x^t) = s_t(x_t)$,

(ii) the principal's expected profit in any period is zero,

(iii) (e_t, s_t) is identical to the optimal contract that would be offered
in the "one-period problem" in which the agent retires at the end of the
initial period (T=0) and the available technology is that of period t.

Corollary: Suppose, in addition to the hypotheses of Theorem 4 that Assumption
8 holds. Then there is an optimal contract in which, for all $t = 0,\ldots,T$, $e_t = e_0$, and $s_t(x^t) = s(x_t)$. Thus the net present value of the agent's total
compensation when he retires with history x^T is

$$\sum_{t=0}^{T} \delta^t s(x_t) .$$

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<u>Proof of Theorem 5</u>: By Theorem 2, Assumptions 1, 2, and 6 imply that Assumptions 4 and 5 hold as well and Assumption 7 plainly implies Assumption 3. Therefore, by Theorems 1-2, there exists a sequentially optimal series of short-term contracts such that (ii) holds. Since both preferences and technological opportunities after any history z^τ depend only on τ, the set of optimal continuation contracts beginning at z^τ depends only on τ. Thus, without loss of optimality, the continuation contract at date 1 can be chosen not to depend on x_0; its continuation at date 2 can be chosen not to depend on x^1, etc. This verifies claim (i).

In view of conclusion (i) and (5.6), the agent's maximal expected future utility at the beginning of period $\tau+1$ if his current wealth is $w_{\tau+1} = w$ and he is employed under some incentive-compatible contract (e,c,s) is expressible as:

(5.7) $$\text{Max}_{c} \; u(c-v(e_{\tau+1})) + \delta E_e\{u[(1-\delta)\delta^{-1}(w+h(P)-c+s_{\tau+1}(x_{\tau+1}))]\}$$

$$= H(P) \; \text{Max}_{d} \; u(d-v(e_{\tau+1})) + \delta E_e\{u[(1-\delta)\delta^{-1}(w+-d+s_{\tau+1}(x_{\tau+1}))]\}.$$

where P is the probability distribution of future incomes and efforts under the optimum continuation contract and we have made the change of variables $d = c - (1-\delta)h(P)$. In view of (5.7), the agent's preferences over action-income lotteries (or short-term contracts) for period $\tau+1$ does not depend on τ, the continuation lottery P, or the date $\tau+1$, except through the technology specified for that date. Obviously, the same is true for the principal's preferences. Hence, the optimum (e_t, s_t) depends only on the period t technology, and (iii) is verified. ∎

The optimal contract specifies the employee's actions each period as a

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function of the current technology and his compensation as a function of the current outcome (which depends only on the current action). The contract requires no "memory", and the ability to provide correct incentives in this model is not enhanced by having the employee write a long-term contract (or relationship) with the employer. Further, each period's contract is the same as it would be if this were the only period in which the agent worked. We should emphasize that these "one-period contracts" are not the same as those which would be optimal if the agent only <u>lived</u> for one period; even when the agent works only once, he lives (and consumes) infinitely often.[2]

The Corollary asserts that when the environment is stationary the agent's aggregate compensation depends on the total number of times each possible outcome has occurred, corrected for discounting. Thus the optimal contract is linear in suitably defined accounting aggregates. (Caution: this does not mean the contract is linear in, for example, the total dollar volume of the agent's sales, but rather that it depends on the number of sales of each possible kind.) This result corresponds to the result on aggregation over time obtained by Holmstrom and Milgrom (1987) for a multiplicatively separable exponential specification.

6. <u>Small Discount Rates</u>.

One might wonder how our results on the optimality of short-term contracts relate to the literature on "folk theorems" in repeated principal-agent problems (Radner 1981, 1985, Rubinstein 1979, Fudenberg and Maskin 1986).

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[2]Actually, one can show that (i)-(ii) of Theorem 3 continue to hold even when the agent is finitely lived after retirement. In that case, (iii) fails because the agent's preferences over contracts depend on the length of his remaining lifetime. The optimal compensation scheme for each period will then depend both on the current technology and on the number of periods of remaining life.

These papers show that when there is no or sufficiently little discounting, efficient payoffs can be approximated by the payoffs of a perfect equilibrium, so that the need to provide incentives is not very costly when δ is near to one. In those papers, unlike ours, there is no banking and there are no enforceable contracts: The principal's promise of future rewards for appropriate behavior is only as good as his incentive to deliver them. Thus, the equilibrium sets of the two types of models are not directly comparable. Nevertheless, it is instructive to note that a "folk theorem" - like result obtains in our model: Letting δ approach one leads to payoffs that approach those achievable in the absence of moral hazard. This occurs even though (under the conditions of Theorem 5) a long-term contractual relationship has no advantage over a series of short-term ones and even though the agent's work life is the fixed finite number T.

This limiting efficiency result can best be understood as follows. The reason that the optimal contract cannot generally attain the first-best is the familiar conflict between the needs to insure the agent from risk and to provide him with the correct incentives. We show below that as δ approaches one, the agent's risk premium for any particular income lottery approaches zero, so the need for insurance vanishes. Then, the first-best incentives can be provided at minimal cost by paying the agent the gross revenues each period.

To see how this works, fix $T = 0$, so that the agent works only once. His lifetime utility is then $u(c_0 - e_0) + (\delta/(1-\delta))u((1-\delta)w_1)$, so his preferences over income lotteries resulting from first period compensation are represented by $u((1-\delta)s_0)$. This utility function has a constant coefficient of absolute risk aversion equal to $(1-\delta)r$, which tends to zero as δ tends to unity. Intuitively, the agent becomes more tolerant of single period income risks as he becomes better able to spread those risks over a long consumption lifetime.

It would be incorrect, in our model, to interpret the approximate efficiency obtained when δ is close to one as representing some advantage from increased frequency of interaction between the principal and agent, because there is approximate efficiency even when $T = 0$ and the agent acts only once.

Fudenberg and Maskin (1986)'s notion of "Enforcement with Small Variation" (ESV) provides an extension of the idea that risk aversion is unimportant when the parties are very patient. Condition ESV obtains in a repeated game with one-sided moral hazard if for any feasible, individually rational utility level $\hat{u}$, it is possible to provide the agent with correct current period incentives by allowing him current utility level $\hat{u}$ and future utility levels that are all close to $\hat{u}$. When Condition ESV holds and δ is near to one, the set of equilibrium payoffs in the repeated imperfect information game nearly coincides with that of its perfect information counterpart. This conclusion holds even if the principal and agent are both risk averse and no bank is available to allow consumption to be smoothed over time, so that the smoothed-consumption ("risk neutral") first-best cannot be attained in the perfect information repeated game. An ESV-like condition also obtains in our example of the last paragraph: When δ is near to one, the contract that gives the agent the firm's profits minus a constant provides correct incentives, and has the property that the agent's per-period utility of consumption after period 0 depends only slightly on the period-zero outcome.

7. Extensions.

Many principals. One can extend our model to situations in which the agent switches employers from time to time to make best use of his human capital. Note that our model already permits the endogenous development of general or specific human capital, since it allows the "technology" in each

period to depend on history.

An earlier version of our paper developed all the preceding results under the assumption that there are many principals. If the principals can contract jointly with the agent, the results reported in this paper are easily extended, for the several principals can then be treated for analytical purposes as if they were a single employer. The joint contract could specify that some payments be made by a principal who is not currently the agent's employer, for example to encourage the acquisition of firm-specific human capital. Only if the labor market equilibrium assigns all the rents associated with human capital to the agent are such payments generally unnecessary.

A second complication that arises when there are multiple principals and no joint contracting is the "common agency" problem, studied by Bernheim and Whinston (1986). Here, the contract offered by any one principal may upset the incentives in the contracts offered by the others. This problem could be removed if exclusive employment contracts could be made and enforced, but the analysis of that problem will not be undertaken here.

Multiple Agents. Joint production, in which several agents are contribute to determining the success of an enterprise, is another natural direction in which our results can be extended. Under conditions similar to those specified in the preceding sections, efficient contracts can always be replaced by equivalent sequentially efficient ones.

The analysis is somewhat different when the "principal" works, and so is in effect another agent. It is well-known that in one-period models, joint production of this sort leads to free-rider problems (even with all parties risk neutral), if one requires that all returns must be distributed among the productive agents (see Holmstrom, 1982). We conjecture that if compensation

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rules are subject only to the weaker constraint that the total compensation in any period may not exceed that period's gross revenues (with the balance being effectively disposed of, for example by a "charitable" contribution) and if natural analogues of the Common Knowledge and Decreasing Utility Frontier conditions hold, then for every efficient contract there is an equivalent sequentially efficient one. If this conjecture is correct then long-term contracts and relationships do not help to solve the free rider problem.

Incomplete Contracts. Our analysis is of relevance for the emerging literature on incomplete contracts (Williamson (1985), Grossman and Hart (1986)), because it identifies an important range of cases in which short-term contracts are all that is needed to support efficient arrangements. In particular, our analysis does not support the common argument that relationship-specific investments must always be protected by long-term contracts in order for proper investments to be made. For more on this point, see Crawford (1986) and Milgrom and Roberts (1987).

Long-Term Relationships. Joint production of a particular kind can arise when different agents may operate the same technology over time. This kind of joint production occurs when one agent retires or is moved to another job, because of comparative advantage. This raises an interesting question: Does job rotation entail contractual efficiency losses? Put differently: When are there contractual gains to long-term relationships?

Our main result identifies one set of circumstances in which long-term relationships are without value (disregarding benefits that arise from experience and the like). It is important to note, however, that even if there are information lags so that long-term contracts are desirable, that does not of

itself dictate a long-term relationship. One could continue the agent's pay after he departs from the job, where payments are contingent on those aspects of performance that are related to his past activities. However, if the agent's job is taken over by somebody else and if the future outcomes will depend both on the first and the second agent's efforts, a new problem may arise. Job rotation will induce an intertemporal free-rider problem if the products of the two agents cannot be identified separately. This free-rider problem can provide a reason for a long-term relationship (continuity in the job) rather than just a long-term contract.[3]

We do not claim that intertemporal linkages always favor long-term relationships. It could be, for instance, that the only way to shirk without being surely detected is to coordinate activities across two periods. Then it might be optimal to rotate workers through assignments to make shirking more difficult (by the same token, banks often demand that clerks take vacations so that fraud can be more easily detected). Similarly, if the agent better knows the potential of the technology that he operates, it may be desirable to rotate jobs in order to get independent readings of the potential (this reduces the well-known ratchet problem). Nevertheless, the intertemporal team example mentioned above is an important one, because it captures the spirit of many investment decisions. A manager's efforts in training subordinates lower today's profits but improve tomorrow's profits, which also depend on tomorrow's

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[3]One can construct an example to verify this along the following lines. There are two periods. Work is performed in both periods, but the effects are only observed after the second period in the form of a binary outcome (success or failure). The information structure is such that any contract that induces work in the first period automatically induces work in the second. Consequently, if two agents were used, one would waste the incentives that the contract for the first agent already provides for second period effort. This is costly, since incentive contracts impose risk (with risk neutral agents the problem would not arise). It is more efficient to let a single contract serve double duty.

efforts. Most investments consume resources today and only partially determine future outcomes. Casual observation suggests that when the innovating manager is not also the implementing manager, the difficulty of assigning responsibility (especially for failures) can become a major source of discontent within firms.

Alternative Rent-Sharing. We have assumed so far that a zero future profits condition for the firm captures the labor market constraints and determines which efficient contract the parties would agree to at any date. To study more general bargaining environments with other possible divisions of surplus, we would need to specify more explicitly the parties' outside opportunities (which determine the "threat point") at each date and the bargaining solution that applies. A long-term contract then requires no commitment (and hence is "equivalent" to a series of short-term contracts) if the timing of payments under the contract can be arranged to make the solution of the continuation bargaining problem always match the continuation utilities under the contract. There appears to be an interesting class of economic environments and bargaining solutions for which such rearrangements are possible, provided the other conditions of Theorem 2 are satisfied. We hope to elaborate this point in a sequel.

8. Conclusion.

In the Introduction we motivated our study in terms of the observed variety in incentive schemes used for different types of workers. Why are managerial workers paid differently than salesmen or factory workers? We found an answer in the nature of their work. Many more of the activities of managers than of factory workers or salesmen contribute directly to future
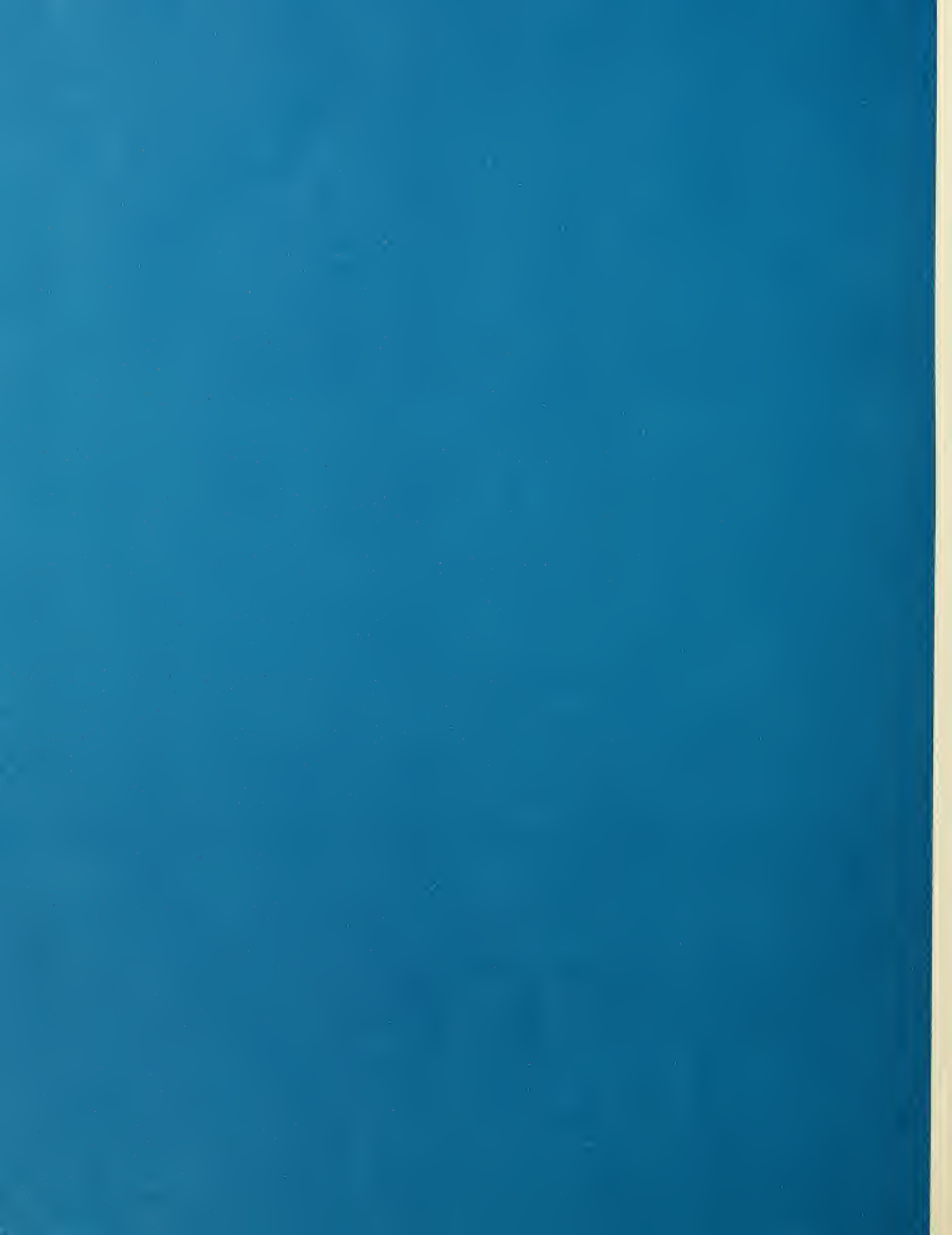
production in ways that are not reflected in current performance measures. Long-term contracts, which await the arrival of additional information on current activities, are important in managerial contracting but not in contracting with workers for whom current observations are sufficient for evaluating current performance.

Our formal analysis has considered lifelong and single period contracts, but most actual employment contracts are of more moderate terms. What can be said about the relationship between the length of contracts and the extent of information lags? Our results suggest an obvious conjecture: The benefits of extending contract length are positively related to the length and extent of the information lag. Consequently, one would expect contracts to be designed to balance the gains from incorporating all the information relevant to the current contract period against the costs of lengthening the contract term. Similarly, our analysis suggests the conjecture that employee turnover in jobs which do not exhibit substantial information lags is higher than in jobs that do. Further development of our model will be needed to generate a set of testable hypotheses of this sort.

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